Quality control is used in an analytical laboratory to check that the results being produced are fit for purpose. A laboratory will typically have its own in-house quality control measures (internal QC), but it may also be involved with outside bodies who provide checks on the quality of results (external QC).

In this topic you will learn about the use of QC standards and control charts for internal QC and proficiency testing schemes for external QC, but first you will learn about the use of method validation for ensuring that analytical methods are fit for purpose.

On successful completion of this topic you will:
- understand features of quality control and quality assurance (LO2).

To achieve a Pass in this unit you will need to show that you can:
- explain internal quality control measures (2.1)
- review the benefits of external quality control (2.2)
- explain the use of control charts (2.4).
1 Method validation

An important process in ensuring that analyses are fit for purpose is to validate the analytical method. Method validation involves testing various parameters to ensure that they are fit for the intended use (some of these have already been covered in Topic guide 4.2):

- bias/trueness
- recovery
- precision (repeatability and/or reproducibility)
- selectivity/specificity – the ability to measure the analyte without interference from other analytes, impurities, matrix species, precursor or degradation products or other components that may be expected to be present
- linearity – the ability (within a given concentration range) to obtain test results that are directly proportional to the concentration of analyte in the sample
- working range – the concentration range over which acceptable uncertainty can be achieved (this is usually greater than the linear range)
- limit of detection – the lowest amount of analyte (or concentration of analyte in a sample) that can be detected but not necessarily quantified as an exact value
- limit of quantitation – the lowest amount of analyte (or concentration of analyte in a sample) that can be quantitatively determined to an acceptable level of uncertainty
- ruggedness – the ability to produce valid data despite small variations in the procedure that might occur in a laboratory where several analysts are performing the same procedure.

Not every parameter has to be determined for every type of analysis – this will depend on the nature of the analysis required, which is usually one of the following:

- the identification of unknown substances (qualitative analysis)
- determining whether levels of an analyte do not exceed or fall below set limits
- quantitative tests for major, minor, trace or ultratrace components.

If the method is to determine the identity of a substance, the analysis must be selective, and you need to know the limit of detection, but it is not necessary to check for linearity or bias. If the method is to determine an analyte that is a major component then you will not need to consider the limits of detection or quantitation as the analyte levels will be much higher than these, whereas if the analyte is a trace or ultratrace component, then the limits of detection and quantitation are very important.

In addition to the parameters given above, the overall measurement uncertainty for the analysis must be estimated.

Activity 4.3.1

If your laboratory undertakes any method validation, choose one of the methods and find out all the details you can about the process the laboratory went through, including what parameters were determined.

Take it further

To learn more about method validation, look at the National Measurement System (NMS) website (www.nmschembio.org.uk), which is full of useful information.

2 Standards and reference materials

When a method is being validated, it is necessary to have reference standards containing known amounts of analyte in order to be able to determine the validation parameters. **Certified reference materials (CRMs)** are materials that have been produced and characterised in a technically valid manner, and are accompanied by a certificate stating the property (for example, analyte concentration), its uncertainty and its traceability (how the analysis of the CRM was itself validated).

CRMs may be pure substances, standard solutions or matrix reference materials.

Examples of pure substances that are certified for chemical purity include pesticides such as cyhalothrin as standards for chromatography.

An example of a standard solution that is certified for concentration is ethanol in water as a standard for ethanol in blood determinations.

Matrix reference materials consist of certified concentrations of analytes within particular matrices, for example, pesticides in whole milk powder. The analytes may either be naturally occurring in the matrix, or the matrix may have been ‘spiked’ with one or more analytes, i.e. had a known amount of analyte added.

Once a method is in routine use in a laboratory, it is necessary to check regularly and frequently that it continues to give the correct results, within an acceptable level of uncertainty. Problems can arise if, for example, instruments or glassware go out of calibration, or an analyst makes a one-off mistake such as making up a reagent solution incorrectly.

In order to ensure that a method continues to produce valid data, QC standards are analysed alongside actual samples. QC standards have compositions that are very similar to the samples being analysed with accurately known concentrations of analyte(s). The QC standards, whether made up and characterised in-house or externally, need to be homogenous so there is minimal uncertainty from sampling, and stable so that one batch can be used over an extended time to ensure consistency in the analyte concentrations from run to run. In addition to QC standards, reagent blanks that contain the sample matrix but without analyte are also normally included as part of the QC procedure.

Sometimes replicate samples may be run to check for consistency between samples – the same sample is run two or more times, usually at different stages in the batch of runs (and not one straight after the other).

A particular example of the use of replicates is in the analysis of samples taken from athletes as part of doping control. Each sample is split into two – the A and B samples. If sample A tests positive for a banned substance, then sample B is analysed, and, if this also tests positive, the athlete is considered to have tested positive for the banned substance.

---

**Key terms**

Certified reference material (CRM): A reference material characterised by a metrologically valid procedure for one or more specified properties accompanied by a certificate stating the value of the property, the uncertainty and its metrological traceability.

Reference material: A material, sufficiently homogenous and stable with respect to one or more properties, that has been established to be fit for its intended purpose.
Activity 4.3.2
Look up one or more of the following websites of organisations that produce certified reference materials.

- Select a catalogue or category of reference material relevant to your workplace.
- Look at the range of reference materials available, and then select a few to look at in detail.
  Examples could include milk CRMs: whole milk powder, skim milk powder; whey powder; certified for fat content, pesticides, aflatoxins, trace elements, radioactive isotopes, etc.

Uncertainty limits are sometimes given in the catalogue, but will always be included on the certificates of analysis. You might also find specimen examples of certificates of analysis for various reference materials.

Write down details of two different CRMs, including the analytes, the matrix, concentrations, uncertainties and what analysis the CRM is used for, and add these to your portfolio.

European Reference Materials (www.erm-crm.org)
http://www.erm-crm.org/Pages/ermcrmcatalogue.aspx

LGC Standards (www.lgcstandards.com)

Institute for Reference Materials and Measurements (http://irmm.jrc.ec.europa.eu)

Activity 4.3.3
Look on the World Anti-Doping Agency (WADA) website for their list of prohibited substances (see www.wada-ama.org). How many examples of CRMs for some of the prohibited substances can you find in the catalogues you looked at in Activity 4.3.2?

3 Monitoring performance – control charts

While the results from the routine monitoring of an analysis using QC standards can be considered in isolation, they are much more powerful when used to generate control charts. A control chart is a graphical method for monitoring the day to day performance of an analysis or a manufacturing process. Control charts may reveal trends that in themselves do not yet result in rejection of analytical results or products, but give early warning of issues or problems that are developing.

The accuracy of an analysis or manufacturing process is monitored using one or more of the following control charts:

- Shewhart control chart
- moving average control chart
- CUSUM control chart.

Shewhart control charts

An example of a Shewhart control chart is shown in Figure 4.3.1. A line for the target value for the analysis is marked on the chart, and additional lines are marked above and below the mean to act as warning and action limits. The value of the QC standard for each batch is plotted on the y axis, and the batch number (or measurement number) is plotted on the x axis.

If more than one QC standard is included in a run the values are averaged and the average plotted. If the analysis (or process) is working satisfactorily the points should be randomly distributed about the target value and between the upper warning limit (UWL) and lower warning limit (LWL).
The warning limits are expected to be breached once in about 20 occasions, i.e. 5% of the time. If they are breached more frequently the analysis (or process) needs investigating. If the action limits (upper action limit, UAL and lower action limit, LAL) are breached then immediate action is required to investigate and rectify the situation. Even if the warning limits are not breached there may be problems which the chart will identify:

- bias, shown by points predominantly one side of the mean
- drift, shown by points following a trend up or down
- a change in some aspect of the analysis (for example, a reagent concentration) shown by a step change in the data.

A key decision is where to set the limits. If they are set too wide then problems may not be spotted, but if they are set too close then acceptable results may be rejected.

The normal practice is to set the warning limits at the target value $\pm 2\sigma$ (where $\sigma$ is the standard deviation of a large number of replicate analyses) and the action limits at the target value $\pm 3\sigma$. If more than one QC standard is included in a batch then the results of the $n$ QC standards are averaged, the warning limits are the target value $\pm \frac{2\sigma}{\sqrt{n}}$ and the action limits are the target value $\pm \frac{3\sigma}{\sqrt{n}}$.

**Moving average control chart**

A modification of the Shewhart control chart is the moving average chart in which the average results of a given number of batches is plotted, instead of plotting the result for each individual batch.

Each point plotted will be the average of that batch, plus a given number of batches immediately before it. This smoothes the data making trends easier to see, but delays the appearance of changes affecting the analysis. The warning limits are the target value $\pm \frac{2\sigma}{\sqrt{n}}$ and the action limits are the target value $\pm \frac{3\sigma}{\sqrt{n}}$ where $n$ is the number of batches used to calculate the moving average.

Figure 4.3.2 shows the data from the example Shewhart chart in Figure 4.3.1, plotted as a moving average chart, with the QC results from four batches (i.e., $n=4$) averaged.
CUSUM Control Chart

A third type of chart, which shows up trends more quickly than a Shewhart chart, is the CUSUM (Cumulative SUM) chart. In this chart, the difference between each QC value and the target value (QC result – target value) is calculated, taking note of the sign. The differences are added and plotted against batch number.

If the analysis is working satisfactorily the points will wander about 0 (the x axis). If there is a problem with the analysis or process, the points will move away from the x axis, up or down. The data used for the previous two charts is presented as a CUSUM chart in Figure 4.3.3.

If the limits on a control chart are breached, the lab first has to decide if any action is required and, if so, what action. The warning limits are expected to be breached once in 20 occasions, therefore no action may be required for a single breach when all other points lie within the warning limits and are randomly distributed around the target mean.

If there is a breach of the action limits, or more than one breach of the warning limits, the analysis or process needs to be checked. Is equipment, such as pumps or heaters, working correctly? Are balances, timers, thermostats, analytical instruments, etc. still within calibration? Are reagents of the correct concentration – have they been made up correctly and are they still in date?
The trend of the points on a Shewhart chart can be suggestive. For example, a drift up or down indicates a steady change in some condition such as base-line drift on an instrument, whereas a step change indicates that a marked change has occurred in the process or analysis at some stage, for example, a new batch of standard which has been made up incorrectly.

Activity 4.3.4
The QC laboratory of a manufacturer of generic aspirin tablets (300 mg, supermarket own brand) analyses QC samples in each batch as a check on the analysis. The target value of the QC standard is 300.0 mg. The optimum value for the standard deviation, $\sigma$, is 5.0 mg, and the number of QC samples analysed, $n$, per batch is three (one each at the beginning, middle and end of each batch of analyses). The data for batches 17 to 35 is shown in Table 4.3.1.

- Plot a Shewhart control chart for batches 20–35. The limits for the Shewhart chart are shown in Table 4.3.2 ($n=3$, for three QC samples per batch).
- Calculate the four-batch average for each of the batches 20–35 (for batch 20 use the average of batches 17–20, for batch 21 use the average of batches 18–21, for batch 22 use the average of batches 19–22, etc.).
- Plot a moving average control chart for batches 20–35. The limits for the moving average control chart are shown in Table 4.3.3 ($n=4$ for four batches being averaged).
- Calculate the differences, i.e. the value − 300.0 mg, for each of the batches 17–35. Calculate the cumulative sum for each batch – this will be 0.1 mg for batch 17, 0.1 + 2.7 mg for batch 18, 0.1 + 2.7 − 3.2 for batch 19, etc. Plot a CUSUM chart for batches 20–35.
- Comment on your three control charts.

<table>
<thead>
<tr>
<th>Batch number</th>
<th>Value / mg</th>
<th>Moving average / mg</th>
<th>Difference (value − 300) / mg</th>
<th>CUSUM / mg</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>300.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>302.7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>296.8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>303.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>298.9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>300.8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>305.4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>301.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>302.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>297.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>304.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>301.9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>305.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>300.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>307.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>299.6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>302.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>34</td>
<td>305.4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>35</td>
<td>304.8</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Activity 4.3.4 continued

Table 4.3.2: The limits for the Shewhart chart for Activity 4.3.4.

<table>
<thead>
<tr>
<th>Limit</th>
<th>LAL</th>
<th>LWL</th>
<th>UWL</th>
<th>UAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value</td>
<td>291.3 mg</td>
<td>294.2 mg</td>
<td>305.8 mg</td>
<td>308.7 mg</td>
</tr>
</tbody>
</table>

Table 4.3.3: The limits for the moving average control chart for Activity 4.3.4.

<table>
<thead>
<tr>
<th>Limit</th>
<th>LAL</th>
<th>LWL</th>
<th>UWL</th>
<th>UAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value</td>
<td>292.5 mg</td>
<td>295.0 mg</td>
<td>305.0 mg</td>
<td>307.5 mg</td>
</tr>
</tbody>
</table>

Activity 4.3.5
If your laboratory uses control charts, make notes on one of these.

Take it further
For a control charts case study on the NMS website see:
http://www.nmschembio.org.uk/GenericListing.aspx?m=422
Read AMC Technical Brief number 46, ‘Internal quality control in routine analysis’, which discusses issues relating to the use of control charts:
http://www.rsc.org/Membership/Networking/InterestGroups/Analytical/AMC/TechnicalBriefs.asp.

4 Monitoring performance – proficiency testing

Laboratories may wish for, or indeed may be required to have, an external check on their performance, for example, if the analysis is being accredited (see Topic guide 4.4). Proficiency testing (PT) schemes are a means of independently assessing the performance of analytical laboratories in specific tests. They are an important part of QA systems in analytical laboratories as they provide an objective and independent means of assessing and demonstrating the reliability of data. PT schemes are usually referred to as external quality assessment (EQA) schemes in life sciences laboratories.

The procedure of a PT (or EQA) scheme is generally for participating laboratories to be sent identical samples to test. Their results are collected and analysed, and the results reported back to each laboratory. Anonymity is preserved by assigning each laboratory a number. Laboratories producing poor-quality results can seek advice from PT scheme organisers to improve their performance.

In laboratories undertaking chemical analysis, a standard method of comparison is the $z$-score.

This is calculated using equation (1), where $x$ is the lab’s result, $x_a$ is the assigned value and $s_a$ is the assigned or target standard deviation.

$$ \text{(1) } z\text{-score} = \frac{x - x_a}{s_a} $$

$z$-scores in the range +2 to −2 are satisfactory, and indicate analytical accuracy. $z$-scores in the range $|2$ to $3|\text{ indicate questionable results, and } z$-scores in excess of $|3|$ indicate poor results, as shown in Figure 4.3.4.

Key term
Proficiency testing (PT): Determination of laboratory performance by means of inter-laboratory comparisons.
The z-scores are often presented as a bar chart with the most negative z-scores on the left-hand side, the smallest in the centre, and the most positive on the right. An example of the presentation of z-scores is shown in Figure 4.3.5.

Alternatives to the z-score include the $E_n$ number and the $Q$ score. The $E_n$ number is calculated using equation (2), where $u_x$ is the expanded uncertainty in the lab's result and $u_a$ is the expanded uncertainty in the assigned value.

$$E_n = \frac{x - x_a}{\sqrt{u_x^2 + u_a^2}}$$

$|E_n| \leq 1$ is a satisfactory performance while $|E_n| > 1$ is an unsatisfactory performance.

The $Q$ score is less robust than the z-score or $E_n$ number as there is no target standard deviation or uncertainty to set the acceptable range of results. It is calculated using equation (3):

$$Q = \frac{x - x_a}{X_a}$$

In life sciences laboratories, for example, hospital, veterinary, environmental health and public health laboratories, many of the analyses undertaken are not straight determinations of the concentrations of analytes, and therefore there is not necessarily a simple score to compare and rank laboratories in an EQA scheme.

For example, in cell pathology laboratories that screen biopsies and smears for cancerous or other cell abnormalities, EQA schemes determine the quality of work by having the laboratories send back tissue samples that they have stained, monitoring the results and interpretations of analyses, and monitoring how the results are reported and what information is provided to clinical staff. Laboratories are graded on whether the tissue samples show the correct features and whether the laboratories have followed the correct reporting protocol.
Microbiology laboratories test for the presence or absence of particular bacteria and fungi, many of which are pathogens (disease-causing organisms). They also isolate and identify bacteria by species or genus, and determine if particular species show antibiotic resistance.

Since each laboratory has usually already been provided with its samples, there are various sources of error that may affect the measurement or analysis:

- sample pretreatment (for example, digestion, extraction, separation, preconcentration, culture or staining of biological samples)
- analytical method (unsuitable or inappropriate for the required analysis; incorrect reagents; sample handling; mistakes in technique and deviations from SOP)
- final measurement (for example, calibration errors, spectral interferences, peak overlap, base-line corrections, background corrections)
- interpretation and evaluation of biological specimens (for example, cell cultures, tissue specimens)
- laboratory facilities (for example, management, laboratory accommodation, insufficient or unsuitable equipment)
- staff (for example, levels of expertise and training, care applied to the work, awareness of pitfalls, workload, frequency of performing the analysis).

PT schemes cover many areas of analysis. Some examples are given in Table 4.3.4:

<table>
<thead>
<tr>
<th>PT scheme</th>
<th>Scope</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aquacheck</td>
<td>waters, soils, sewage sludge and waste waters</td>
</tr>
<tr>
<td>CONTEST</td>
<td>toxic contaminants in soil</td>
</tr>
<tr>
<td>HPA EQA</td>
<td>microbiological quality of water and food</td>
</tr>
<tr>
<td>(Health Protection Agency External Quality Assessment)</td>
<td></td>
</tr>
<tr>
<td>FAPAS</td>
<td>food analysis</td>
</tr>
<tr>
<td>FEPAS</td>
<td>food microbiology</td>
</tr>
<tr>
<td>(Food Examination Performance Assessment Scheme)</td>
<td></td>
</tr>
<tr>
<td>GeMMA</td>
<td>genetically altered food</td>
</tr>
<tr>
<td>(Genetically Modified Material Analysis Scheme)</td>
<td></td>
</tr>
<tr>
<td>BAPS</td>
<td>beer</td>
</tr>
<tr>
<td>(Brewing Analytes Proficiency Scheme)</td>
<td></td>
</tr>
<tr>
<td>ProTAS</td>
<td>alcohol in beer</td>
</tr>
<tr>
<td>UK NEQAS</td>
<td>clinical chemistry, histopathology, haematology, immunology, microbiology</td>
</tr>
<tr>
<td>(National External Quality Assessment Scheme)</td>
<td></td>
</tr>
<tr>
<td>RICE</td>
<td>asbestos in the construction industry</td>
</tr>
<tr>
<td>Vetqas</td>
<td>clinical chemistry, histopathology, haematology, immunology, microbiology in farm animals and horses</td>
</tr>
<tr>
<td>WASP</td>
<td>hazardous airborne substances</td>
</tr>
<tr>
<td>MAPS</td>
<td>barley, malt and malt flour</td>
</tr>
<tr>
<td>(Malt Analytes Proficiency testing Scheme)</td>
<td></td>
</tr>
<tr>
<td>LEAP</td>
<td>potable water chemistry, microbiology and parasitology; wastewater and soils chemistry</td>
</tr>
<tr>
<td>(Laboratory Environmental Analysis Proficiency Scheme)</td>
<td></td>
</tr>
<tr>
<td>QWAS</td>
<td>microorganisms in potable, mineral, bathing, surface, sea and waste waters</td>
</tr>
<tr>
<td>(Quality in Water Analysis Scheme)</td>
<td></td>
</tr>
</tbody>
</table>
Activity 4.3.6

A proficiency testing scheme was set up for the analysis of sorbic acid in chutneys (see Table 4.3.5). Sorbic acid-free chutney was spiked with 200 mg kg\(^{-1}\) sorbic acid (the assigned value). The target standard deviation was 2.64 mg kg\(^{-1}\).

Calculate the \(z\)-scores and identify the laboratories giving questionable and poor results.

<table>
<thead>
<tr>
<th>Laboratory number</th>
<th>Sorbic acid concentration / mg kg(^{-1})</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>201.48</td>
</tr>
<tr>
<td>2</td>
<td>198.97</td>
</tr>
<tr>
<td>3</td>
<td>187.82</td>
</tr>
<tr>
<td>4</td>
<td>202.16</td>
</tr>
<tr>
<td>5</td>
<td>197.54</td>
</tr>
<tr>
<td>6</td>
<td>193.31</td>
</tr>
<tr>
<td>7</td>
<td>204.38</td>
</tr>
<tr>
<td>8</td>
<td>195.25</td>
</tr>
<tr>
<td>9</td>
<td>206.07</td>
</tr>
<tr>
<td>10</td>
<td>200.96</td>
</tr>
</tbody>
</table>

Table 4.3.5: Proficiency testing results for Activity 4.3.6.

Case study: EQA and *Escherichia coli* (*E. coli*)

*Escherichia coli* (*E. coli*) is a widely occurring bacterium. Certain strains, for example, *E. coli* 0157, are pathogenic and cause food poisoning. UK NEQAS (analysis of samples in clinical and hospital laboratories), Vetqas (analysis of samples from farm animals and horses and other agricultural samples) and the Health Protection Agency (microbial testing of food and water) all have EQA schemes that include the determination of *E. coli*.

In the UK NEQAS general bacteriology scheme for the isolation and identification of bacterial pathogens, which includes *E. coli* 0157, 12 sets of samples are distributed per year to participating laboratories. Each set has three simulated clinical samples that may contain a single pathogen, or two pathogens in a ‘mixed’ sample. Each correctly identified pathogen is given a score of 2, while an incorrectly identified pathogen scores −1. A negative result (no pathogen present) or unidentified pathogen score 0. The total score for each set for each laboratory is averaged to get a mean score, and the standard deviation determined. Laboratories whose score is more than 1.96 standard deviations below the mean may be performing poorly. Details, including the ‘correct’ results, are given on a report to each laboratory. Poorly performing laboratories can ask to have repeat samples so that they can identify where they made errors.
Activity 4.3.7

In the UK NEQAS scheme for detection of MRSA, two samples are sent six times a year. There is a score of 2 for a correct result so the maximum score in each distribution is 4. The performance rating is based on the cumulative score of three distributions. The mean score for all participants was 11.77 out of a maximum of 12, with a standard deviation of 1.23. From the scores given in Table 4.3.6, identify which of the labs show a satisfactory performance, and which show a poor performance.

Table 4.3.6: Lab scores for Activity 4.3.7.

<table>
<thead>
<tr>
<th>Lab</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>11.89</td>
</tr>
<tr>
<td>B</td>
<td>10.23</td>
</tr>
<tr>
<td>C</td>
<td>9.02</td>
</tr>
<tr>
<td>D</td>
<td>11.67</td>
</tr>
</tbody>
</table>

Take it further

Follow the links below to read more about the UK NEQAS microbiology scheme, and the HPA schemes:
http://www.hpa.org.uk/ProductsServices/MicrobiologyPathology/ExternalQualityAssessmentProficiencyTesting/

The following link shows the format of a UK NEQAS report and explains its features:

Activity 4.3.8

Your workplace may be involved in internal or external proficiency testing schemes. You may even have taken part yourself. If so, note down some brief details: what the scheme is, how often your lab is sent samples, what kind of analysis is done, what use your laboratory has made of feedback from the scheme organisers, etc.

Use the links below to find details of a scheme from a different area of analysis from your own type of work.

If your workplace is not involved in a PT scheme, find details of a few schemes from different areas of analysis via the Internet. See if you can find one related to your laboratory’s type of work. Try the following websites for examples:
http://vla.defra.gov.uk/eqa/PTschemes.htm
http://www.ukneqas.org.uk/content/Pageserver.asp
http://www.fapas.com/proficiency-testing-schemes/
Take it further
http://www.rsc.org/Membership/Networking/InterestGroups/Analytical/AMC/TechnicalBriefs.asp
Use this link to the National Measurement System website to find more information on proficiency testing.

Portfolio activity (2.1, 2.2, 2.4)
Write a report on quality control in your lab or workplace.
• Describe what day-to-day methods are used to ensure that results are accurate, such as the use of QC samples and control charts.
• Note what routine checks on equipment and reagents are carried out, and how these are recorded and monitored.
• Note whether reference materials or reference samples are used and explain how and when they are used.
• Comment on whether your own work is checked and/or signed off by your supervisor or line manager.
• Note whether the lab participates in internal or external proficiency testing. If so, explain how the proficiency testing scheme works, and discuss how feedback from the proficiency test results are used to monitor and improve the performance of lab staff, commenting particularly on how it applies to you.
• Note and comment on any other quality control features in your laboratory.

Further reading
Quality Assurance in Analytical Chemistry (E. Prichard and V. Barwick, 2007), Wiley
Biomedical Science Practice: Experimental and professional skills (H. Glencross, N. Ahmed and Q. Wang, 2010), OUP

Acknowledgements
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